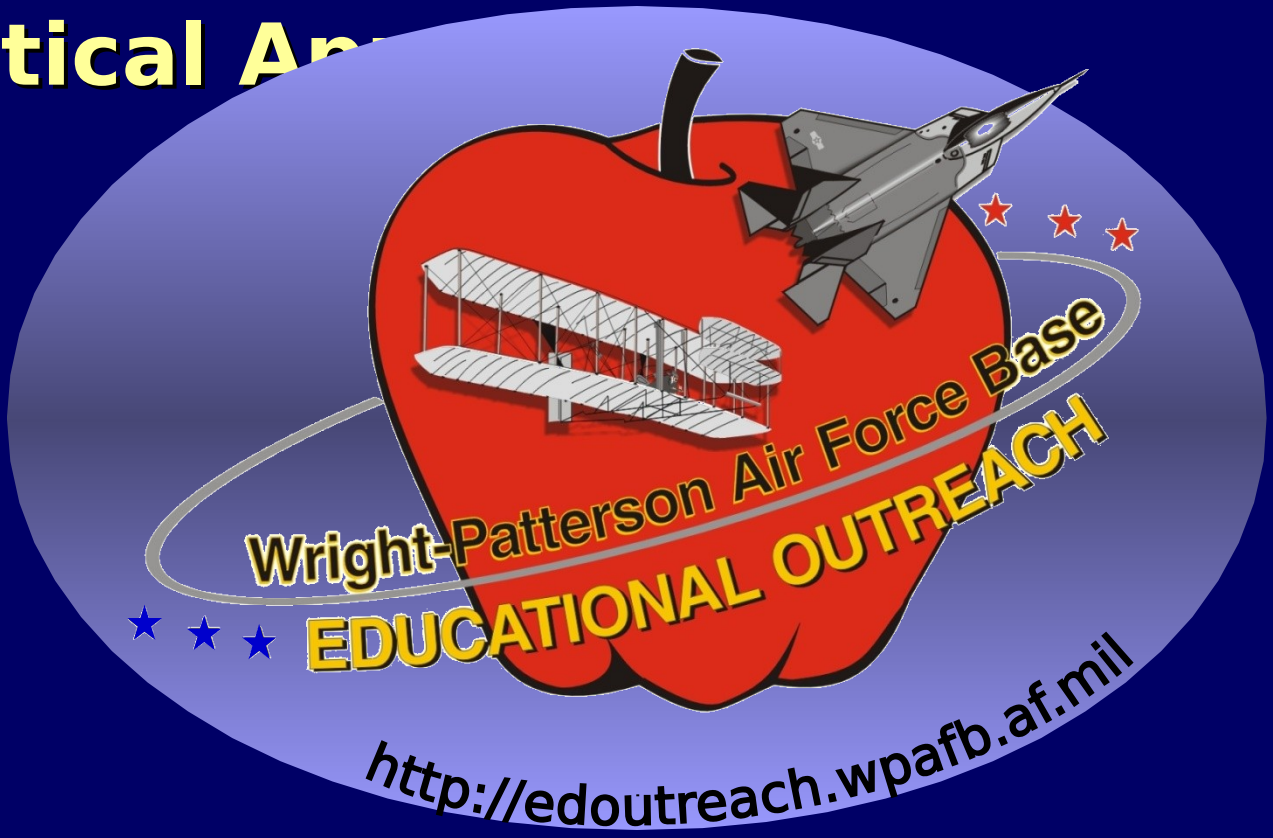
Science & Engineering Fairs:

A Practical Ap



WRIGHT PATTERSON
Air Force Base, Ohio
The Birthplace, Home and Future of Aerospace

Dr. Rita Peterson
AFRL Sensors Directorate
Senior Research Physicist
(937) 904-9657

Mr. Bob Gemin
WPAFB Educational Outreach
Engineering Specialist
(937) 656-2273

When Somebody Says "Science Fair" . . .

What's the first thought that pops into your head???

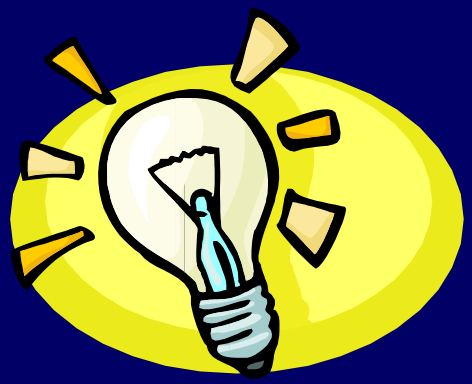
A Science Fair Is…

- More work!
- Required for a grade
- Only for geeks/nerds
- Confusing!!
- Fear of unknown!!!

What should you think?

How you'll feel after the Science Fair:

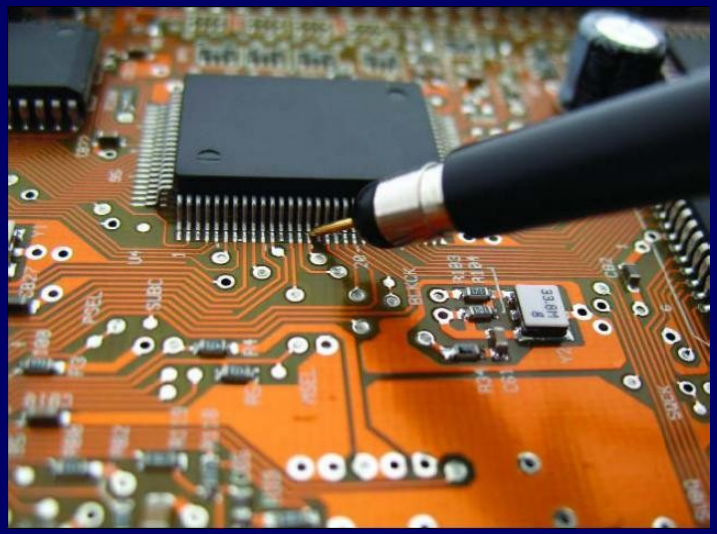
- **I'm proud of myself for doing a great job!**
- **It was fun to be in charge of my own project.**
- **I showed Mom and Dad what I can really do.**
- **Wow - I never realized _____!**
- **I want to learn more about _____.**



There are many reasons to participate! What's yours???

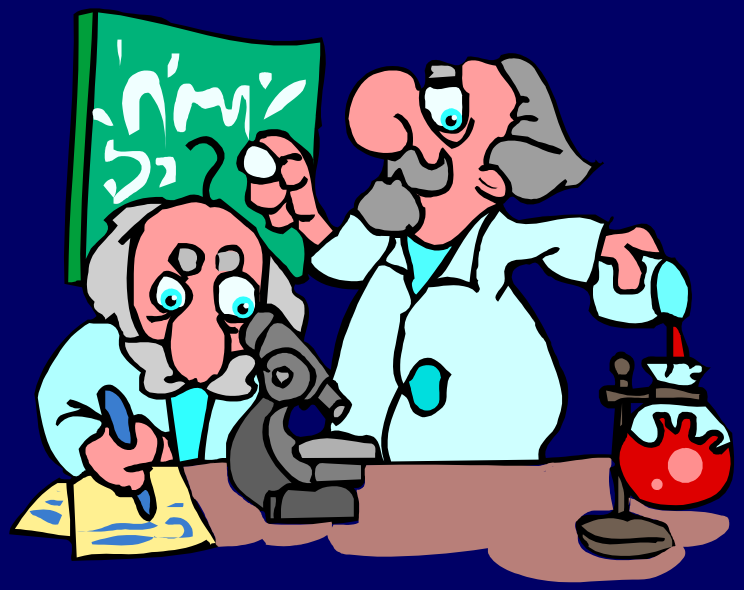
Computers? Cell phones? Rockets to Saturn, probes to the ocean floor, GPS systems, gameboys, X-boxes?

All developed by scientists and engineers.



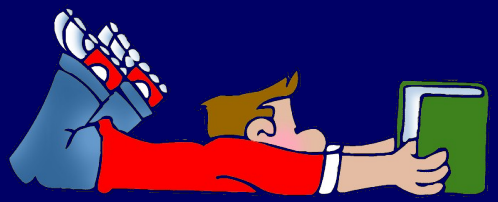
A Science Fair Project Is An Opportunity

- Explore new things
- Develop valuable skills
- Improve self- confidence
- Meet interesting people
- Sometimes win prizes/money



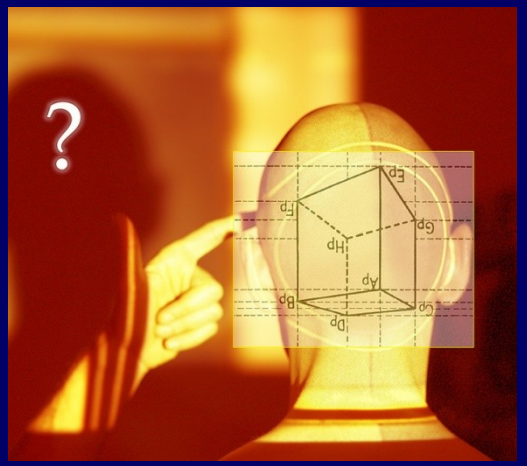
A Science Fair Project Involves Many Subjects

- Science
- Math
- Reading
- English/writing
- Art/design
- Social Studies
- Music/sports/etc.

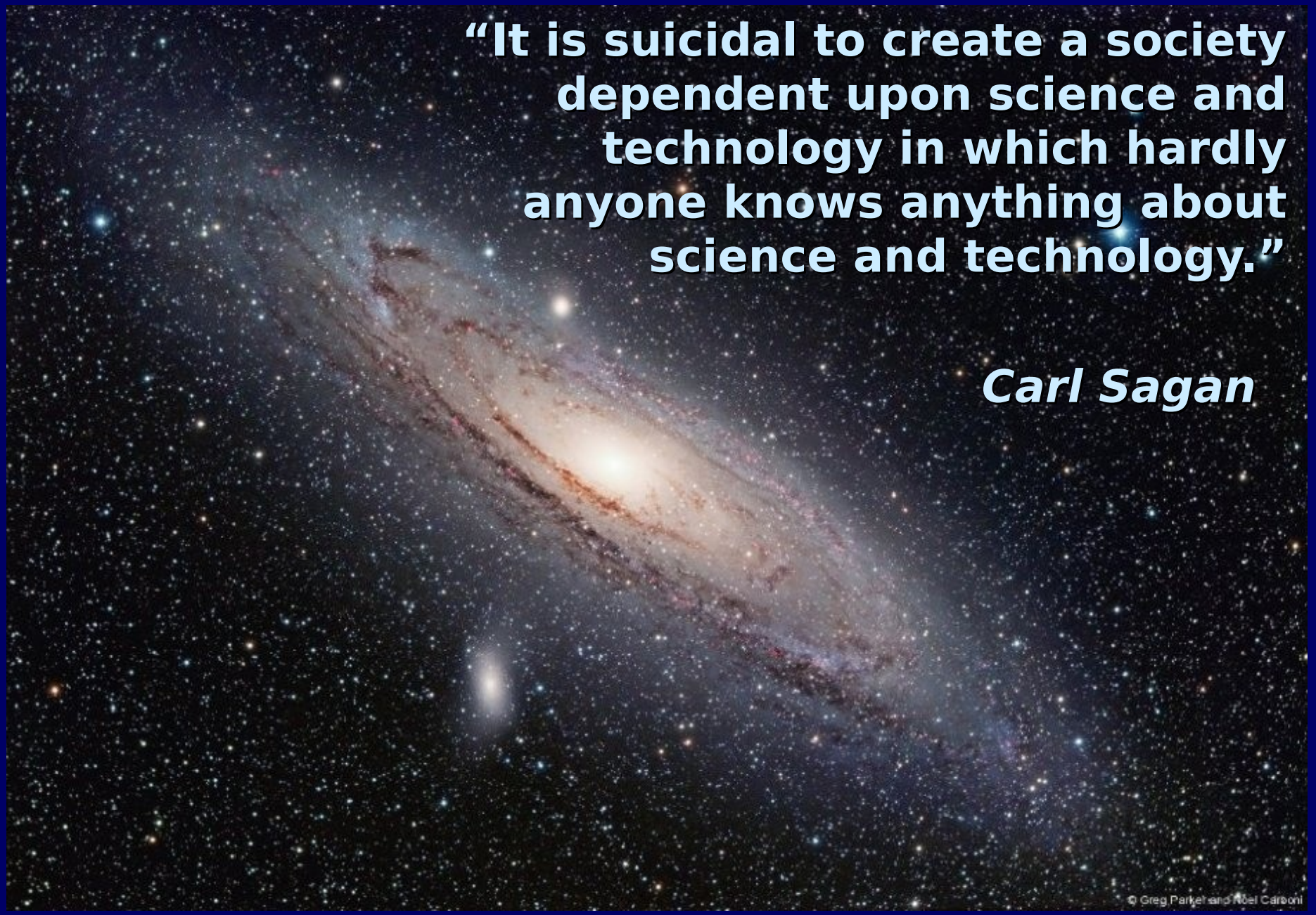


A Science Fair Project Develops Useful Skills

- Using the scientific method
- Creative problem solving
- Critical thinking skills
  - fact vs. opinion
  - logic vs. assumption
- Time and project management
- Communication - writing and speaking
- Efficient, judicious use of information
- Confidence, poise and thinking on your feet.



Every human being can benefit from these


“It is suicidal to create a society dependent upon science and technology in which hardly anyone knows anything about science and technology.”
Carl Sagan
© Greg Parker and Noel Carboni

The Science Fair Recipe

QUESTION

RESEARC

HYPOTHESIS

PROCEDURE

EXPERIMENT

RESULTS

ANALYSIS

CONCLUSION

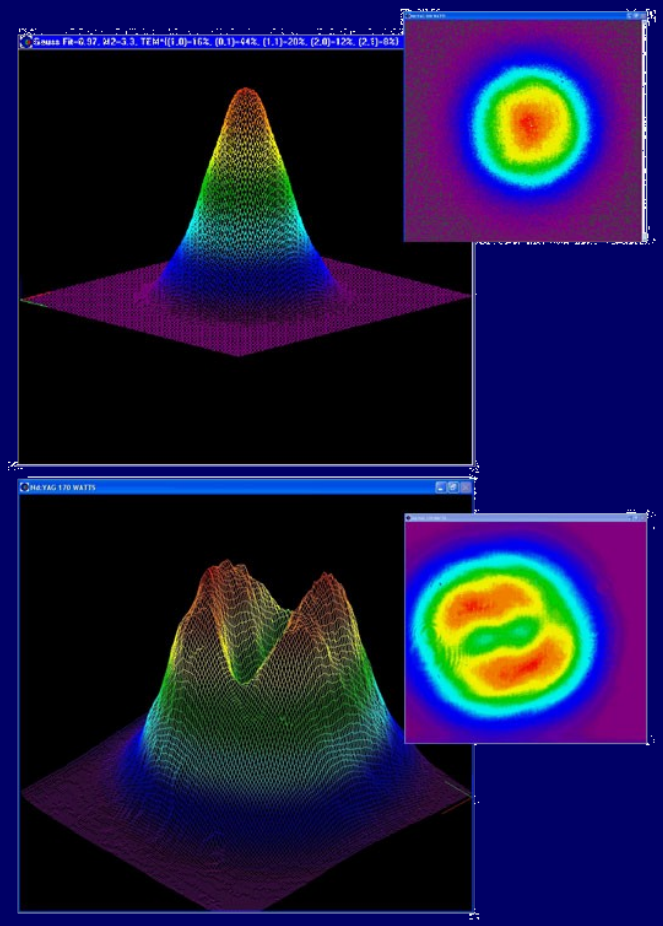
Scientific Method

How is Science Done in the Real World?

- No one is the lone ranger
  - Everyone has help: colleagues, mentors, technicians, etc.
  - Crediting the work of others is essential
- No idea is entirely original
  - Everything builds upon what came before
  - Much valuable research is incremental
- We can't always formulate a specific
- Experiments rarely work the first time
- "Failures" really can be valuable
- Communication is as important as result

Science is a way of finding things out. It's a way of testing what's real. It's what Richard Feynman called "A way of not fooling ourselves."

Developing a Question



A good science fair topic is:

- **Interesting and exciting**
- **Manageable in scope**
- **Doable with available resources**
- **Experimental**
- **Quantifiable (what will you plot?)**
- **Original and creative (what can you do that is different?)**

Getting ideas

- Start with a list

INTERESTS	KNOWLEDGE/ SKILLS	MENTOR	RESOURCES
BASKETBALL	MATH	ROY - PAINTER	VIDEO CAMERA
FANTASY/RPGs	COMPUTER GAMES	JANE – GARDENING	BLOOD PRESSURE MONITOR
AIRPLANES	BASKETBALL	BOB – ELECTRONICS	THERMOMETERS
WEATHER	WOODWORKING	SALLY – NURSE	FISH TANK

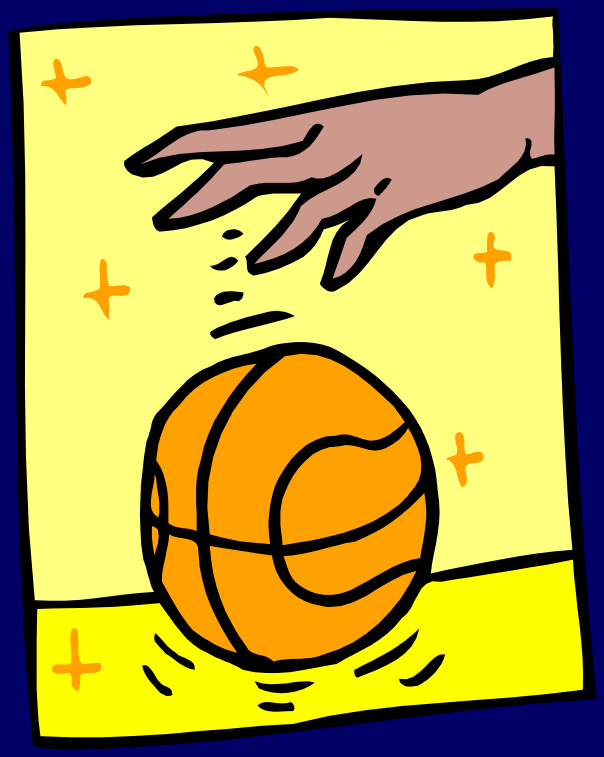
Getting ideas

- **Start with a list**

INTERESTS	KNOWLEDGE/ SKILLS	MENTOR	RESOURCES
BASKETBALL	MATH	ROY - PAINTER	VIDEO CAMERA
FANTASY/RPGs	COMPUTER GAMES	JANE – GARDENING	BLOOD PRESSURE MONITOR
AIRPLANES	BASKETBALL	BOB – ELECTRONICS	THERMOMETERS
WEATHER	WOODWORKING	SALLY – NURSE	FISH TANK

- **Surf the web**
- **Talk with a possible mentor**
- **Think of your favorite science lesson**
- **Daydream: what makes you wonder?**

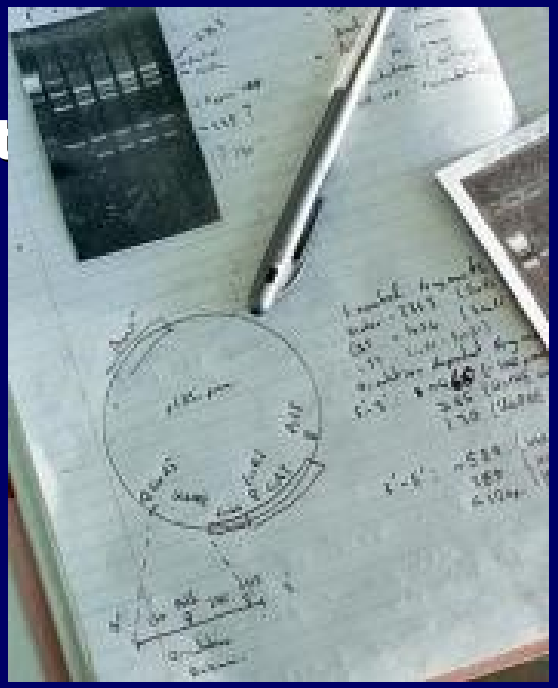
An example:



How high will a basketball bounce when inflated to different pressures?

Doing Research

- **Commit to documenting your work**
  - Record everything, even if it seems inconsequential
  - No one ever puts enough detail in their notebook
- **Research underlying scientific principles**
  - Informs educated guesses to answer your question
  - Helps with design of experiment, equipment
- **Internet searches are great… but don't forget books, journals, and people**
  - More on this later!!
  - Make note of sources for proper attribution



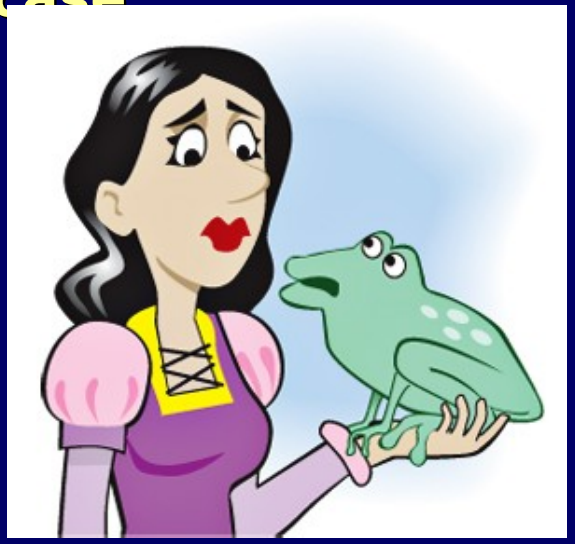
Get a notebook!!

STEP #2 - RESEARCH

Forming a Hypothesis

The hypothesis rewords your question in a way to help you do your experiment

- **It is <u>not</u> a wild or uninformed guess**
- **It <u>should</u> be based upon what you already know about your question**
- **Be prepared to explain it**
- **Engineering projects may be a special case**

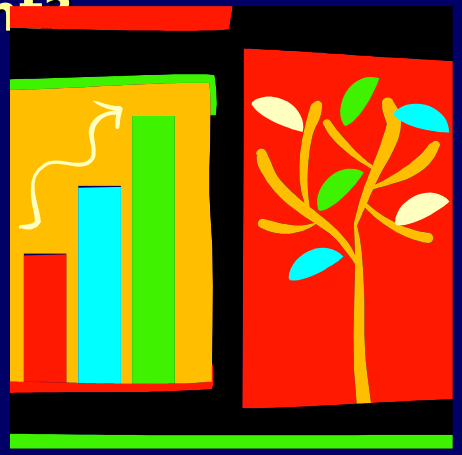


STEP #3 -

Procedure/Experiment – Design Is Critical

Measure something that can be quantified

- What are you measuring?
- How will you collect the data?
  - equipment
  - method
- How many data points do you need?
- How many times will you repeat the experiment?
- What is the error/uncertainty in the data?



STEP #4, 5 –

Getting Results

- The better you prepare, the more straightfoward the test
- Follow your procedure carefully and consistently
- Record everything – even failures
  - Record all experimental conditions
  - Record observations like noises/smells
  - Take pictures of test setup
- Document anything that might have an impact (someone opened an outside door and let cold air in)

STEP #6 - RESULTS

“It is a capital mistake to theorize before one has data. Insensibly one begins to twist facts to suit theories, instead of theories to suit facts.”

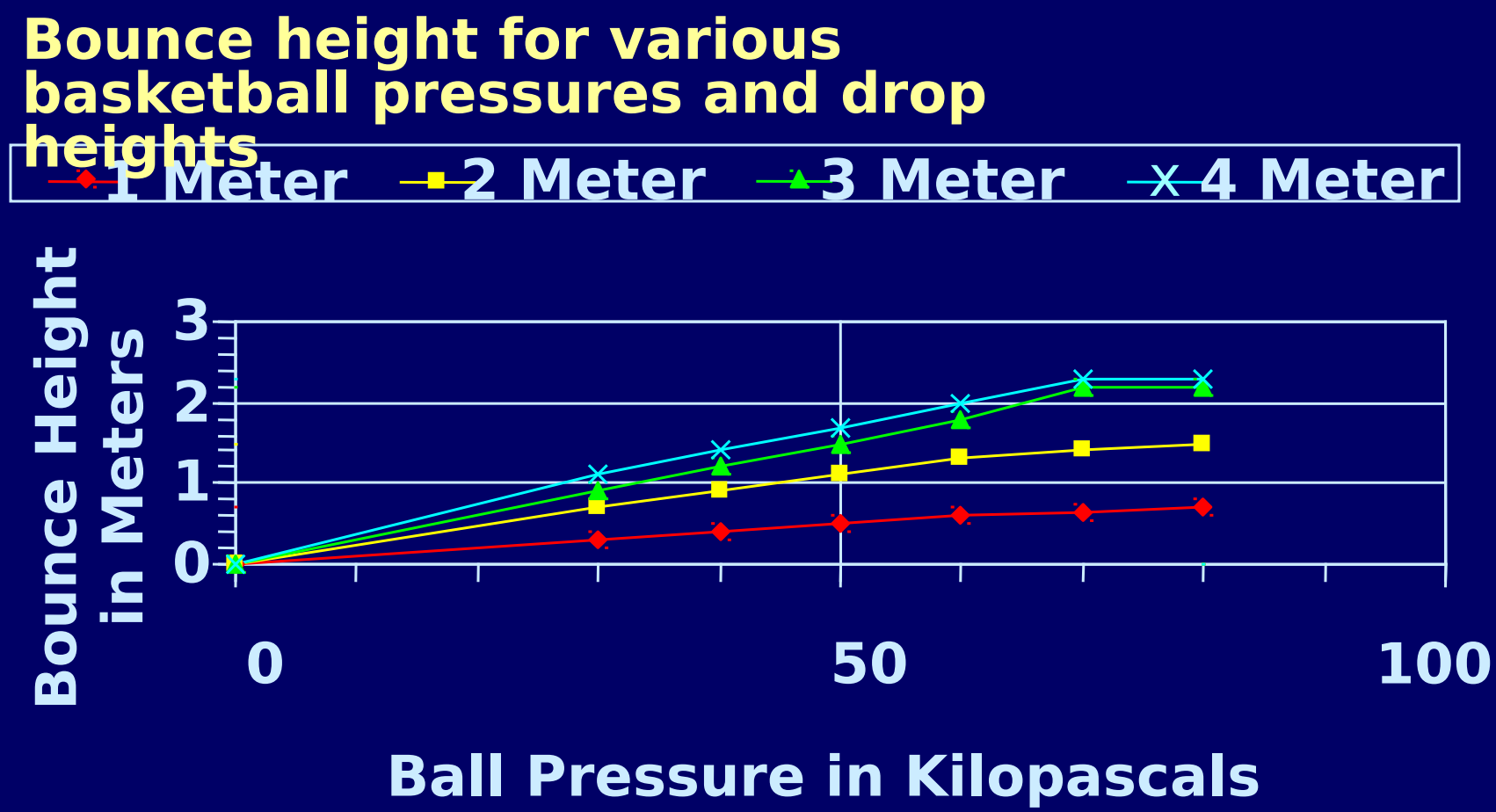
Sherlock Holmes in Arthur Conan Doyle’s A Scandal in Bohemia (1891

Analysis – one step at a time

Start by plotting your data

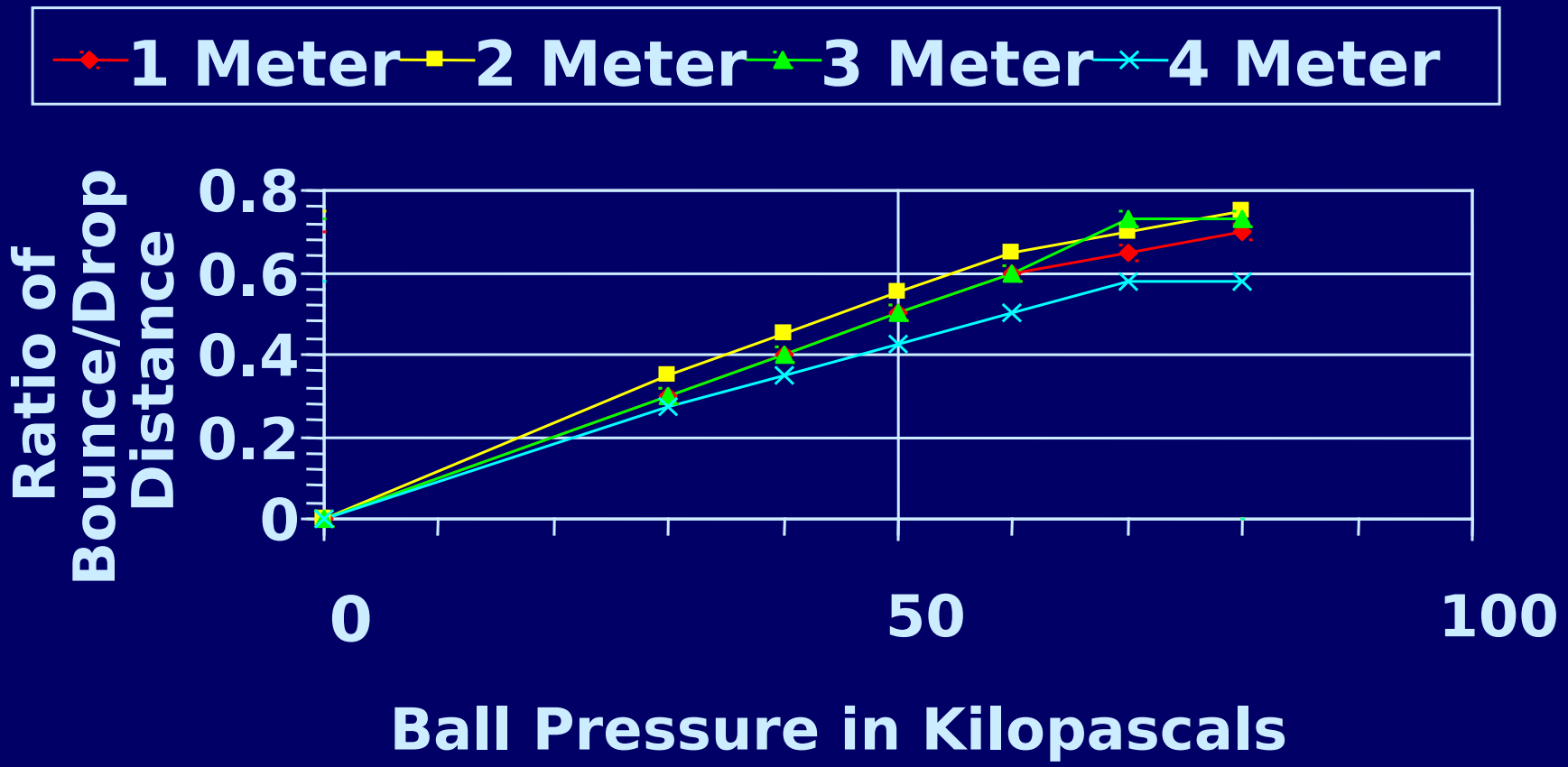
- Is the plot linear? What are the slope, intercepts, max and min values? What do these mean?
- How do plots of different runs compare?
- Plot the same data different ways to highlight different observations
- Use statistics if helpful to combine data
- Spreadsheets are powerful tools - but make sure you know how to plot data by hand first!!!

Example 1 - obvious



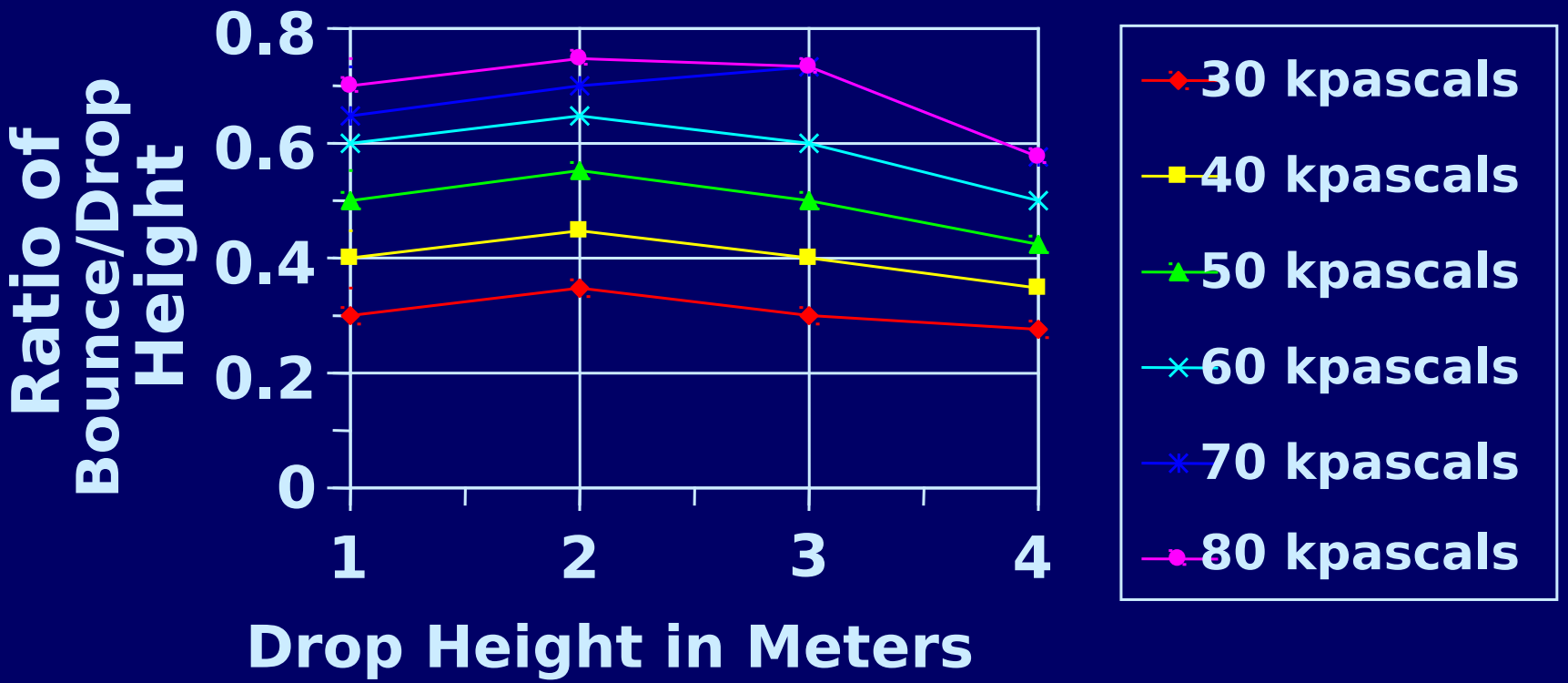
Example 2

Bounce ratio vs. ball pressure for various drop heights



Example 3

Bounce ratio vs. drop height for various ball pressures



Error / Uncertainty

- "Error" doesn't mean that you made a mistake
  - often factors in environment that can't be controlled
  - weigh impact of error vs. difficulty to control
  - identify error sources in your analysis
- Every measuring device has limits (precision)
- Every subject of study will have different variation

STEP #6 - ANALYSIS

Conclusions

- Don’t just repeat yourself
- Summarize key points from your results
  - How accurate are they?
  - What is their meaning or significance?
- Focus on answering your question/hypothesis
  - Your project is not a failure if your hypothesis was wrong
  - If your hypothesis is disproven, offer an explanation
  - Now that you have an answer, what is it good for?
- How might you do things differently, or expand upon your results? Suggest future tests, or related projects

STEP # 8 -

Avoid Common Mistakes

- Sample size too small – need more trials
- More than 1 uncontrolled variable at a time
- Nothing readily quantifiable in project
- Scope too broad - can't cover parameter space with time, resources available
- Scope too narrow/project too simple
- Plots not labelled right, not explaine wrong type, too many
- Conclusions not explained
- Display contains errors or is too flash

Making the Most of Mentors (including parents):

- Find mentors with ability, expertise to meet your needs
  - relatives, neighbors, friends
  - teachers, coaches
  - internet contacts (ask your parents first)
- Be respectful of their time
- Be prepared with specific questions
- Listen to them!
- Arrange to meet again; ask for more leads
- Thank and acknowledge them

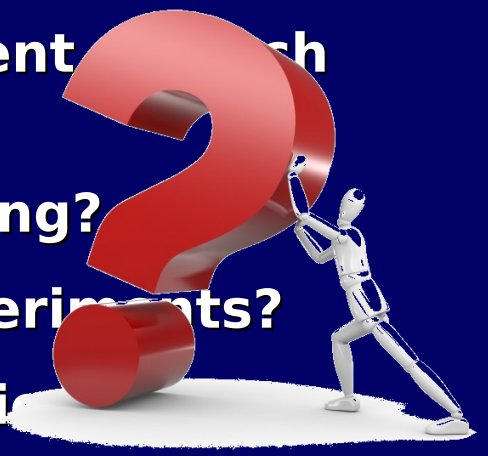
Scientists and engineers enjoy sharing what they love with young people . . . like YOU!

Prepare For Presentation

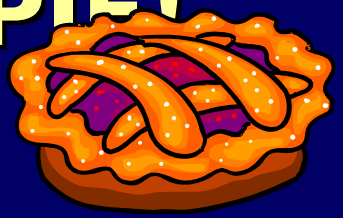
- Prepare and practice your presentation
  - Follow the scientific method outline
  - Explain what you did and why, what you saw, and what it means
  - Identify what is original about your project
  - Use your poster as a cheat sheet
  - Practice on friends, parents, etc.
- Anticipate likely questions
  - Research the answers
  - Make note cards as reminders
  - Practice/memorize them

Typical Questions

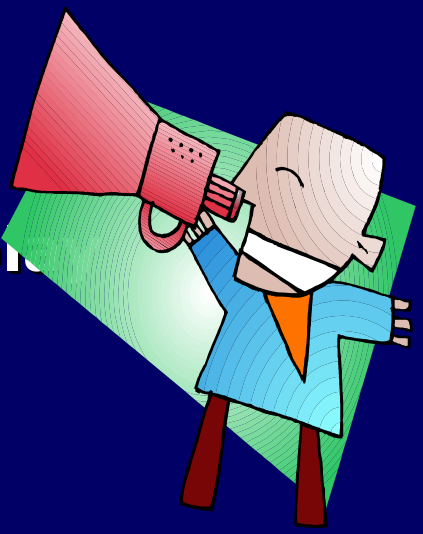
- Where did the idea for this project come from?
- What did you learn from your research?
- What were the most important sources used in your research?
- How much time did you spend on the project? What took most of your time?
- Where did items used in your project come from?
- How many times did you run the experiment for each configuration?
- Did you use any statistics such as averaging?
- How constant were conditions during experiments?
- What would you do differently, or in addition?



Selling Yourself – Use PIE!



- Performance – already covered
- Image - impression you give in appearance, actions
  - Help the judges see their history in your future
  - Speak, act, dress like a young professional
  - Show them you enjoy what you are doing; tell stories, share extra things you have learned
  - Ask questions – play to their expertise
- Exposure – grab attention with your displ
  - But take note of any rules and restrictions
  - Make sure it is free of errors, typos, etc.



Did We Mention "Having Fun"? :

- People throughout history have experimented with science and engineering "for fun"
- Imagine getting paid for doing something you enjoy doing
- To avoid stress: start your project early, be ready… then kick back and enjoy

For Additional Information:

WPAFB Educational Outreach Office

- (937) 656-2273
- (937) 904-8033 fax
- website: http://edoutreach.wpafb.af.mil
- email: wpafb.educational.outreach@wpafb.af.mil

Bob Gemin

- Engineering Specialist
- (937) 656-2273
- (937) 904-8033 fax
- email: Robert.Gemin2@wpafb.af.mil

Major funding for the WPAFB Educational Outreach Program is provided by the Air Force Research Laboratory